

Claims

1. An absolute position encoding apparatus comprising:
  - a scale element (100) having a first code track and a second code track formed thereon said element;
  - 5 a light source (110,111) for illuminating said code tracks;
  - an area array sensor (115,116) configured to receive the light illuminating said code tracks for imaging a portion of said first and second code tracks simultaneously, said area array sensor capable of imaging onto a pixel matrix having a plurality of rows;
  - 10 means for reading a first detector line (410) corresponding to a row in the pixel matrix comprising the first code track,
  - means for reading a second detector line (420) corresponding to a row in the pixel matrix comprising the second code track;
  - 15 means for compensating for fluctuations in the code track resulting from the scale element being inaccurately mounted; and
  - processing means for numerically calculating an absolute position based on the imaged code tracks from the scale element.
- 20 2. An encoding apparatus according to claim 1, wherein the scale element is an optical disk suitable for use in a rotary encoder and the first code track represents the incremental track and the second code track represents the absolute track.
- 25 3. An encoding apparatus according to claim 1, wherein said light source is a photoemitter such as an LED, laser diode, or incandescent light source.
4. An encoding apparatus according to claim 1, wherein the area array sensor is constructed of either CCD or CMOS photodiode technology.

5. An encoding apparatus according to claim 1, wherein said light source and said area array sensor are proximally located on a first side of the scale element and a mirror located on a second side, whereby the emitted light is reflected by the mirror through the scale element to illuminate the code tracks for reception by the sensor.
10. An encoding apparatus according to claim 1, wherein the processing means further includes a Field Programmable Gate Array (FPGA) logic circuit for numerically calculating the phase intensity distribution, the spatial frequency and the phase angle of the image of the code tracks.
15. An encoding apparatus according to claim 1, wherein at least two area array sensors are positioned 180 degrees apart such that the incremental and absolute code tracks are read at two different locations resulting in two different angular positions, and wherein the absolute position is based on the mean of the angular positions.
20. 8. An encoding apparatus according to claim 2, wherein the incremental track is comprised of a plurality of equally spaced and radially distributed markings near the outer edge of the disk, and wherein the absolute track is comprised of markings that form a series of coded lines that include broad and narrow lines radially distributed inside the incremental track such that the broad lines divide the track into equally sized sections and within each section are two narrow data lines that carry information about absolute position.

9. An encoding apparatus according to claim 1, wherein the means for compensating include means for dynamically changing the detector line of the incremental track image, when the pattern period changes due to inaccurate mounting of the scale element which causes undesirable spatial movement of the code track, the detector line is shifted so that it always includes an image with the same pattern period.  
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10. An encoding apparatus according to claim 1, wherein the means for compensating include means for altering the numerical value of the pattern period used in the Fourier phase algorithm to match the spatial frequency of fluctuating tracks.  
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11. An encoding apparatus according to claim 1, wherein four area array sensors are positioned 90 degrees apart such that the incremental and absolute code tracks are read at four different locations.  
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12. A Total Station theodolite apparatus (700) used for topographic surveying and mapping includes an optical encoder for measuring angular position in the vertical plane and the horizontal plane and cooperates with a servo-mechanism for automatically tracking a target, wherein said encoder comprising:  
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an optical disk (800,810) having an incremental code track and an absolute code track formed thereon;  
a photoemitter light source (110,111) for illuminating the incremental and absolute code tracks;  
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an area array sensor (115,116) configured to receive the light illuminating said code tracks for imaging a portion of said incremental and absolute code tracks from the disk simultaneously, said area array sensor being capable imaging onto a pixel matrix having a plurality of rows;

means for reading a first detector line (410) corresponding to a row in the pixel matrix comprising the incremental track,

means for reading a second detector line (420) corresponding to a row in the pixel matrix comprising the absolute code track;

5 means for compensating for a shifting code track resulting from inaccurate mounting of the disk;

processing means for calculating an absolute position based on the imaged code tracks from the disk; and

means for calculating the topographic data and tracking information  
10 about the target.

13. A Total Station apparatus according to claim 12, wherein the optical disk opaque with transparent code track markings or a transparent disk with opaque code track markings.

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14. A Total Station apparatus according to claim 12, wherein the photoemitter is an LED, laser diode, or incandescent light source and the area array sensor is an Interline Transfer (ILT) CCD area array sensor.

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15. A Total Station apparatus according to claim 12, wherein the processing means further includes a Field Programmable Gate Array (FPGA) logic circuit for numerically calculating the phase intensity distribution, the spatial frequency and the phase angle of the image of the code tracks.

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16. A Total Station apparatus according to claim 12, wherein at least two area array sensors are positioned 180 degrees apart such that the incremental and absolute code tracks are read at two different locations resulting in two different angular positions, and wherein the absolute position is based on the mean of the angular positions.

17. A Total Station apparatus according to claim 12, wherein the incremental track is comprised of a plurality of equally spaced and radially distributed markings near the outer edge of the disk, and wherein the absolute track is comprised of markings that form a series of coded lines that include broad and narrow lines radially distributed inside the incremental track such that the broad lines divide the track into equally sized sections and within each section are two narrow data lines that carry information about absolute position.

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18. A Total Station apparatus according to claim 12, wherein the calculating means is performed by a processor and a controller for operating the automatic tracking servo-mechanism.

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19. A Total Station apparatus according to claim 12, wherein the means for compensating include means for dynamically changing the detector line of the incremental track image, when the pattern period changes due to spatial movement of the disk, the detector line is shifted so that it always includes an image with the same pattern period.

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20. A Total Station apparatus according to claim 12, wherein the means for compensating include means for altering the numerical value of the pattern period used in the Fourier phase algorithm to match the spatial frequency of fluctuating tracks.

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21. A method of calculating an absolute position with an optical encoder device comprising the steps of:

illuminating with a light source ((110,111) an incremental code track and an absolute code track formed on a scale element (100);

imaging a segment of the incremental and absolute code tracks onto a CCD or CMOS area array sensor (115,116) wherein the segment is imaged onto a pixel matrix having a plurality of rows;

5 reading a first detector line (410) corresponding to a row in the matrix comprising the incremental code track;

reading a second detector line (420) corresponding to a row in the matrix comprising the absolute code track;

compensating for fluctuations in the code tracks resulting from inaccurate mounting of the scale element;

10 calculating numerically the absolute position based on the light distribution of the images of the incremental and absolute code tracks.

22. The method according to claim 21, wherein at least two area array sensors are positioned 180 degrees apart such that the incremental and absolute 15 code tracks are read at two different locations resulting in two different angular positions, and wherein the absolute position is based on the mean of the angular positions.

23. The method according to claim 21, wherein said light source and said area 20 array sensor are proximally located on a one side of the scale element and a mirror located on the other side, whereby the emitted light is reflected by the mirror through the scale element to illuminate the code tracks for reception by the sensor.

25 24. The method according to claim 21, wherein the compensating step dynamically changes the detector line of the incremental track image when the pattern period changes due to spatial movement of the disk, the detector line is shifted so that it always includes an image with the same pattern period.

25. The method according to claim 21, wherein the compensating step includes altering the numerical value of the pattern period used in the Fourier phase algorithm to match the spatial frequency of fluctuating tracks.

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26. The method according to claim 21, wherein at least a Field Programmable Gate Array (FPGA) performs at least a portion of the numerical calculations.

10 27. The method according to claim 21, wherein four area array sensors are positioned 90 degrees apart such that the incremental and absolute code tracks are read at four different locations.

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